RESEARCH ARTICLE

# DO BACKWARD INTEGRATION BOOST THE TECHNOLOGY ADOPTION BY CHILLI FARMERS? THE EVIDENCE FROM ANDHRA PRADESH, INDIA

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**Abstract:** The study intends to analyse the impact of backward integration on technology adaptation by chilli farmers. A sample of 128 farmers has been selected purposively from four mandals of Prakasam district in Andhra Pradesh. Technology adoption index, probit regression and poisson model with endogenous regression model used to analyse the impact backward integration on technologies adoption by chilli farmers. The findings show that majority (46.87%) of the chilli farmers who are following backward integration are adopting maximum technologies with technology adoption index 80-90 and the farmers who are not following backward integration (73.43%) are adopting less than four technologies with adoption index <50. The extension service (0.11) and backward integration (0.53) had a positive significant at 10 per cent and 5 per cent levels effect on adoption of technologies.

**Keywords:** Backward integration, Chilli farming, Technology adoption index, Probit regression, Poisson model

## INTRODUCTION

Market liberalization and growth of international trade have created export opportunities in agricultural sector for many developing countries. The traditional way for food production is replaced by practicing more similar to manufacturing processes, with greater co-ordination of farmers, processors, retailers and other stakeholders in value chain of agriculture. The agro-food sector can be conceptualized as a system of vertically intercorrelated stages. Vertical coordination is harmonizing of vertical inter dependence of the production and distribution of activities. Backward integration is a strategy under vertical integration where a firm gains control over ownership or increased control over its suppliers.

Agricultural processing gaining more importance as export of agricultural commodity was increasing. Spices has a major role in export. Chilli is the major spice contributing 42-44 per cent by volume and 25-28 per cent by value to total spices exported from India (Spice Board of India, 2019). In India, Andhra Pradesh ranked first in area and production of chilli, accounting to 1.59 lakh hectares with a production of 6.3 lakh tonnes and productivity of 3,962 kg/ha during 2018-19. Prakasam district in Andhra Pradesh state occupied 2$^{nd}$ place with 0.58 lakh hectares area and 1.50 lakh tonnes of production during 2018-19 (Agricultural Statistics at a Glance 2018-19).Wide variation in yield levels leading to fluctuation in chilli prices and farmers are facing problems like high transportation cost, low productivity, viral diseases, quality deterioration by contamination of pesticides, industrial chemicals and aflatoxins. It is vitally important to support the chilli farmers to produce high quality, sustainable food safe spices to compete in the international market. The major players like ITC, Synthite etc., are providing customised solutions to diverse challenges of chilli farmers through backward integration.

The main objective of the study is to analyse the impact of backward integration on adoption of technologies in chilli farming.

## METHODOLOGY

The decision to adopt technologies which improve quantity and quality of the produce may be determined by several characteristics of farmers, like age, education, credit, extension visit, farming experience, backward integration and to know the factor to intensify adoption of technologies count data model were used by Isgin *et al.* (2008), Lohr and Park (2002), Rahelizatovo and Gillespie (2004), Ramirez and Shultz (2000), and Sharma *et al.* (2011) employed count data models to explain intensity of adoption of various technologies. A number of other studies (Beshir, 2014; Caviglia-Harris, 2003; Gebremedhin and Swinton, 2003) have considered factors affecting both the decision to adopt and the degree or intensity of adoption of technologies or conservation practices using double hurdle models. These usually involve a first stage probit model and a second stage poission model. Other studies (Mbaga-Semgalawe and Folmer, 2000) use an integrated socio-economic model of adoption to examine a first stage perception of erosion, a second stage adoption of improved soil and water conservation measures, and then a Poisson regression model to analyse a third stage adoption effort (or level of adoption) of improved conservation measures in which selectivity bias is accounted for using the Heckman two-stage approach.

To assess the participation effect of farmers land tenure, activity in social, awareness of backward

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integration, farm size and family size are major part. Several other studies find that farmers land tenure, farm size and family size are important in participation (Baumgart Getz *et al.* 2012).

**Technology Adoption Index**

To measure the technology adoption of chilli farmers, technology adoption index was calculated

$$TAI = \frac{A_i}{M_i} * 100$$

$A_i$ = Adoption score by the farmer

$M_i$ = Maximum adoption score by the farmer

**Poisson Model with Endogenous Treatment:**

To estimate the impact of backward integration on adoption of technologies in chilli farming, poisson model with endogenous treatment was used. A count data model will be suitable for poisson model (Greene, 1997). The method used by Greene, 1997 is adopted, where endogenous regression model for dependent variable *i.e.*, number of technologies adopted by farmer is specified. This specification allows for well-defined correlation structure between the unobservable variable that affects backward integration as well as adoption. The interest model equation was given by

$$E(Y_i/X_i, c_i, e_i) = exp(X_i b + \delta c_i + e_i) \quad \ldots(1)$$

$X_i$ is a vector of covariate that influences the level of adoption. The probability density function for $Y_i$ is conditional on the treatment $c_i$, the covariates $X_i$ and error $e_i$ is given by (2)

$$E(Y_i/X_i, c_i, e_i) = \frac{exp\{-\exp(X_i b + \delta ci + e_i)\}\{\exp(X_i b + \delta ci + e_i)\}^{Y_i}}{Y_i!} \quad \ldots(2)$$

The treatment (backward integration) is determined by (3)

$$c_i = \begin{Bmatrix} 1\ if\ w_i\gamma + u_i > 0 \\ o\ if\ otherwise \end{Bmatrix} \quad \ldots(3)$$

The covariate vectors $X_i$ and $W_i$ are exogenous, estimation of the parameters in such models may be done by using maximum likelihood.

The empirical model that assesses the participation effect in integration on the adoption of technologies is estimate by Probit regression model and Poisson regression with endogenous model, given in two equations below

Backward integration (c) = $\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + u_i$

$X_1$ = Land tenure (1 if own land; 0 otherwise)

$X_2$ = Membership of farmer based organisation (1 if yes; 0 otherwise)

$X_3$ = Awareness (1 if yes; 0 otherwise)

$X_4$ = Distance to market place (1 if <100km; 0 otherwise)

$X_5$ = Farm size (ha)

$X_6$ = Family size (number)

$u_i$ = Error term

Adoption (Y) = $\beta_0 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + \beta_{11} X_{11} + \beta_{12} X_{12} + e_i$

Where Y is a count variable ranging from 0 if a farmer failed to adopt any of the technologies up to 8, the highest number of technologies. The technologies identified in study area and taken for the study is Soil testing, Selection of variety, Agronomic practices, Pesticide and fertilizer application, Utilization of green label/slightly toxic chemicals, Integrated pest management, Integrated crop management and Post-harvest handling.

$X_7$ = Age (number of years)

$X_8$ = Education (1 if educated; 0 otherwise)

$X_9$ = Credit (1 if available; 0 otherwise)

$X_{10}$ = Extension visit (number of times visit per month)

$X_{11}$ = Farming experience (number of years)

$X_{12}$ = Backward integration (1 if integrated farmers; 0 otherwise)

$e_i$ = Error term

**Data and Sampling**

In 2018-2019 conducted a primary survey of integrated farmers, non-integrated farmers and firms in four mandals of Praksam district in Andhra Pradesh. Multistage random sampling technique was adopted for selection of sample at different levels in the present study. In Andhra Pradesh, Prakasam district was selected purposively as the integrated chilli farmers of both ITC and Synthite are present in Prakasam district only. Prakasam district in Andhra Pradesh state occupied 2$^{nd}$ place with 0.58 lakh hectares area and 1.50 lakh tonnes of production during 2017-18. The farmers who are adopting backward integration are integration farmers. The farmers other than integrated farmers are mentioned as non-integrated farmers. Four mandals and from each mandal, two villages were selected based on the highest number of integrated chilli farmers. By using cocharn's (1963) formula sample size was calculated. From each village, 8 integrated farmers and 8 non-integrated farmers were selected, making a total sample of 128 farmers constituting 64 integrated and 64 non-integrated farmers. MS excel and software STAT version 15, a trail version was used to analyse technology adoption index, probit regression and poisson model with endogenous regression model.

**Characteristics of sample farmers**

The data obtained through the primary survey covered a wide range of information on age of the farmers, education level, farming experience, household size, farm size, distance to market, backward integration, land tenure and membership of a farmer based organization, among others. These socioeconomic variables (e.g. Age, Education, *etc.*) are relevant in the sense that it indicates whether a farmer will take part in backward integration or adopt improved farm technology. Chi-square test was done to know the presence of association between variables and backward integration. The variables are significant, means there is a significant association between variables and backward integration.

The results from Table 3.1 indicate that majority of the integrated farmers (67.19%) had formal education while the rest (32.81%) had no formal education, for non-integrated farmers 43.75 per cent are educated and 56.25 per cent had no formal education. From the total sample, majority (55.47%) of them are educated. Educated farmers are able to better process the information, allocate inputs more efficiently, and more accurately assess the profitability of new technology, compared to farmers with no education. 50 per cent of the total sample farmers were under backward integration of some sort while the rest were not. Land ownership is an important factor in every production activity. A large percentage (73.44%) of the integrated farmers and 34.38 per cent of non-integrated farmers owned their land while the rest were tenants who paid some form of rent to the land owners. From the total sample, owned land farmers found to be more than tenant farmers.

**Table 1.** Categorical socioeconomic variables

| Variable | Integrated farmers (n=64) | Non-integrated farmers (n=64) | Per cent to total (n=128) | $\chi^2$ test |
|---|---|---|---|---|
| **Education** | | | | |
| Educated | 43 (67.19) | 28 (43.75) | 55.47 | 8.62** |
| Illiterate | 21 (32.81) | 36 (56.25) | 44.53 | |
| **Land tenure** | | | | |
| Owned | 47 (73.44) | 22 (34.38) | 53.91 | 19.65** |
| Rented | 17 (26.56) | 42 (65.63) | 46.09 | |
| **Member of FBO** | | | | |
| Yes | 19 (29.69) | 10 (15.63) | 22.66 | 3.61* |
| No | 45 (70.31) | 54 (84.38) | 77.34 | |
| **Awareness of backward integration** | | | | |
| Aware | 58 (90.63) | 31 (48.44) | 69.53 | 26.88*** |
| Not aware | 6 (9.38) | 33 (51.56) | 30.47 | |

Note: figures in parenthesis indicate per cent to total, ***Significant at the 1 % level of significance, **Significant at the 5 % level of significance, *Significant at the 10 % level of significance

The majority (70.31%) of the integrated farmers and non-integrated farmers (84.38%) were not members of any of the farmers based organisation (FBO) while the rest were members of FBO. From the total sample, 77.34 per cent are not members of FBO. 90.63 per cent of integrated and 48.44 per cent of non-integrated farmers were having knowledge about backward integration farming and rest of them were not aware of backward integration.

The other socio-economic variables like age, experience, distance to market, farm size and household size are presented in Table 3.2. Age of the respondents ranged between 24 to 65 years, with an average of 41 years. A larger proportion (48.44%) of the integrated respondents were aged between 41 to 60 years while non-integrated farmers had a larger proportion (59.38%) of 21 to 40 years, which are the most productive stages of their lives, all other things being equal. Also, large percentages (45.31%) of the integrated farmers were aged between 21 to 40 years while 6.25 per cent were above 60 years. For non-integrated farmers, 40.63 per cent belongs to the age group of 41-60 years. From the total sample, majority (52.34%) of the farmers belong to 21 to 40 years.

The average years of farming experience of the respondents were 19 years, ranging from 4 to 40 years. A large number *i.e.*, 42.19 per cent of the integrated farmers and 50 per cent of non-integrated farmers had farming experience between 11 and 20 years as shown in Table 3.2. The long years of farming experience can increase farmers' confidence in adopting improved agricultural technologies. 10.94 per cent and 20.31 per cent from the total sample of integrated and non-integrated farmers respectively were having less than 10 years of farming experience. Similarly, 37.50 per cent and 23.44 per cent of the total sample of integrated and non-integrated farmers respectively were having less 21 to 30 years of farming experience. 9.38 per cent and 6.25 per cent from the total sample of integrated and non-integrated farmers respectively were having 31 to 40 years of farming experience. On the part of distance to market, the results show that a majority (43.75%) of the non-integrated farmers travel a distance of 101 kilometers to 150 kilometers. The 31.25 per cent of the non-integrated farmers travel a distance of <100 kilometers to access a market. Integrated farmers travelled less than 100 km to market their products. The 78.13 per cent of the integrated and 45.31 per cent of non-integrated farmers cultivated a land size of >2 hectares. About 18.75 per cent of the integrated farmers and 39.06 per cent of non-integrated farmers cultivated a land size of 1.01 to 2 hectares. 3.13 per cent of integrated farmers and 10.94 per cent of non-integrated farmers cultivated a land size of 0.51 to 1.00 hectares. While a small percentage (4.69%) of the non-integrated farmers cultivated below 0.5 hectares. From the total sample, majority (61.72%) of the farmers were large farmers (>2 hectare).

**Table 2.** Continuous socioeconomic variables

| Variable | Integrated farmers (n=64) | Non-integrated farmers (n=64) | Per cent to total (n=128) | $\chi^2$ test |
|---|---|---|---|---|
| **Age (years)** | | | | |
| <20 | 0 (0.00) | 0 (0.00) | 0.00 | $5.64^{*}$ |
| 21-40 | 29 (45.31) | 38 (59.38) | 52.34 | |
| 41-60 | 31 (48.44) | 26 (40.63) | 44.53 | |
| >60 | 4 (6.25) | 0 (0.00) | 3.13 | |
| Average | 43 | 38 | 41 | |
| **Experience in farming (years)** | | | | |
| <10 | 7 (10.94) | 13 (20.31) | 15.63 | $7.60^{**}$ |
| 11-20 | 27 (42.19) | 32 (50.00) | 46.09 | |
| 21-30 | 24 (37.50) | 15 (23.44) | 30.47 | |
| 31-40 | 6 (9.38) | 4 (6.25) | 7.81 | |
| Average | 20 | 18 | 19 | |
| **Distance to market (Km)** | | | | |
| <100 | 64 (100.00) | 20 (31.25) | 65.63 | $67.04^{***}$ |
| 101-150 | 0 (0.00) | 28 (43.75) | 21.88 | |
| 151-200 | 0 (0.00) | 8 (12.50) | 6.25 | |
| >200 | 0 (0.00) | 8 (12.50) | 6.25 | |
| **Farm size (hectare)** | | | | |
| Marginal (<0.50) | 0 (0.00) | 3 (4.69) | 2.34 | $15.92^{***}$ |
| Small (0.51-1.00) | 2 (3.13) | 7 (10.94) | 7.03 | |
| Medium (1.01-2.00) | 12 (18.75) | 25 (39.06) | 28.91 | |
| Large (>2.00) | 50 (78.13) | 29 (45.31) | 61.72 | |
| **Household size (No.)** | | | | |
| 1-3 | 22 (34.38) | 26 (40.63) | 37.50 | 3.86 |
| 4-7 | 41 (64.06) | 33 (51.56) | 57.81 | |
| >7 | 1 (1.56) | 5 (7.81) | 4.69 | |

Note: figures in parenthesis indicate per cent to total, ***Significant at the 1 % level of significance, *Significant at the 10 % level of significance

The average size of the households was 4 members. A large percentage (64.06%) of the integrated farmers and 51.56 per cent of non-integrated farmers has household sizes that ranged between 4-7 members. From the total sample, majority (57.81%) of the farmers were having 4-7 members family size. A large household is an endowment and a reliable source of labour if household members are available to work on the farm as family labour, given the labour-intensive nature of agricultural technologies.

## RESULTS AND DISCUSSION

### Technology adoption index

The technologies present in the study area in chilli farming and frequency of farmers adopted was showed in Table 4.1. The technologies are soil testing, selection of variety, agronomic practices, pesticide and fertilizer application, utilization of green label/slightly toxic chemicals, integrated pest management, integrated crop management and post-harvest handling. 81.25 per cent of integrated farmers and 21.88 non-integrated farmers are following soil testing technology. Synthite company is providing soil testing for their integrated farmers and most of the ITC farmers tested their soil in the soil laboratory. The company extension agents recommended fertilizer doses to the farmers according to their soil testing results. Selection of variety according to their climatic region and soil health condition and production quantity was mostly adopted 84.37 per cent of integrated farmers and 81.25 per cent of non-integrated farmers. 92.19 per cent of integrated farmers and 70.31 per cent of non-integrated farmers are adopting agronomic practicing technology like spacing and time of sowing. About 96.44 per cent of integrated farmers are adopting the technology related to pesticide and fertilizer application, *i.e.*, the time schedule of application, number of applications and quantity of application. All these techniques are closely examined by the company extension service agents. Only 29 out of 64 members of non-integrated farmers are following these technologies because they don't have knowledge about number of applications and quantity of application of pesticides and fertilizers.

**Table 3.** Technology practice wise frequency distribution of integrated and non-integrated farmers

| S. No. | Technology | Integrated farmers (n=64) | Non-integrated farmers (n=64) |
|---|---|---|---|
| 1 | Soil testing | 52 (81.25) | 14 (21.88) |
| 2 | Selection of variety | 54 (84.37) | 52 (81.25) |
| 3 | Agronomic practices | 59 (92.19) | 45 (70.31) |
| 4 | Time and number of Pesticide and fertilizer application | 62 (96.44) | 29 (45.31) |
| 5 | Utilization of green label/slightly toxic chemicals | 64 (100.00) | 3 (4.69) |
| 6 | Integrated pest management | 64 (100.00) | 19 (29.69) |
| 7 | Integrated crop management | 49 (76.56) | 19 (29.69) |
| 8 | Post-harvest handling | 45 (70.31) | 22 (34.38) |
| $\chi^2$ test: 52.64*** | | | |

Note: values in parenthesis are per cent of the sample size, ***Significant at 1% level of significance
Source: Estimated by author

The farmers who are under backward integration of Synthite company should strictly follow green label chemicals and integrated pest management. ITC company farmers should follow the technologies like utilization of green label/slightly toxic chemicals, integrated pest management and integrated crop management. IPM is the core of food safety strategies to ensure pesticide residue compliant products for export companies. IPM model promotes a corrective approach for pest management through a combination of physical and cultural interventions to reduce agrochemicals consumption. IPM technology transfer is assisting farmers to analyse pest infestation to establish economic threshold levels to optimise pesticide usage, improve productivity & profitability. The integrated crop management is a preventive approach to reduce pest incidence by boosting plant immunity through agronomical interventions. It helps to enhance productivity, reduce cultivation costs and increase profitability.

Few percentages of non-integrated farmers are following technologies like utilization of green label/slightly toxic chemicals (4.69%), integrated pest management (29.69%) and integrated crop management (29.69%). This is due to lack of guidance and knowledge about them. 34.38 per cent of the non-integrated farmers are following post harvest handling technologies. About 70.31 per cent of integrated farmers are following post harvest handling like grading. Grading is most important operation for integrated farmers and this operation is followed under supervision of company agents. Top graded chilli was purchased by company and least graded produce sold in Guntur market.

Level of adoption of technologies was analyzed through technology adoption index (TAI) and the results are presented in Table 4.2. The TAI for each farmer was computed by dividing the number of practices adopted by farmers by total number of practices selected and expressed as percentage. The majority (46.87%) of the integrated chilli farmers were adopted seven technologies with technology adoption index of 80-90 and 12.50 per cent of the integrated farmers adopted six technologies with technology adoption index of 70-80. About 15.63 per cent farmers from total sample were adopted all technologies. Most of the non-integrated farmers (73.43%) are adopting less than four technologies with adoption index of <50 and 9.37 per cent farmers were adopted five technologies with technology adoption index 60-70. Farmers who are under backward integration are adopting more technologies than others. Chi-square test was done for understanding the association between backward integration and technology adoption index. The test was significant at 1 per cent level and it reveals that there is positive association between technology adoption index and backward integration.

The integrated farmers were adopted technologies like pesticide and fertilizer application, utilization of green label/slightly toxic chemicals and integrated pest management. Most of the non-integrated farmers are following technologies like selection of variety, agronomic practices, pesticide and fertilizer application. Very few non-integrated farmers are adopting technologies like soil testing, utilization of green label/slightly toxic chemicals, post harvest management *i.e.*, grading like operations.

**Table 4.** Technology adoption index

| Technology Adoption Index | Number of Technologies | Integrated Farmers (n=64) | Non-Integrated Farmers (n=64) |
|---|---|---|---|
| <50 | 3 | 0 (0.00) | 47 (73.43) |
| 50-60 | 4 | 0 (0.00) | 7 (10.93) |
| 60-70 | 5 | 6 (9.37) | 6 (9.37) |

| | | | |
|---|---|---|---|
| 70-80 | 6 | 8 (12.50) | 4 (6.25) |
| 80-90 | 7 | 30 (46.87) | 0 (0.00) |
| >90 | 8 | 20 (31.25) | 0 (0.00) |
| $\chi^2$ test: 42.54*** | | | |

Note: values in parenthesis are per cent of the total, ***Significant at 1% level of significance
Source: Estimated by author

**Factors Influencing the Participation of Farmers in Backward Integration**

The probability of the model chi-square was found to be 0.00 indicating that model was significant at 1 per cent level and socioeconomic factors influence the farmers to participate in backward integration. The coefficients of the probity regression only show the direction of the effects that an explanatory variable had on the dependent variable. The marginal effects that shows the magnitude of the changes that occur on the dependent variable when there are corresponding changes in the independent variables was also estimated. The results are presented in Table 4.3.

The land tenure of the farmer had a positive influence on farmers participation in backward integration. The marginal effect indicates that when a farmer had own land, the probability of taking part in backward integration was 0.45 per cent greater than tenant farmers. The secure land tenure will encourage adoption decisions so, owned land farmers were more likely to adopt the backward integration. Membership of farmer-based organization (FBO) had no significant effect on the participation in backward integration. Awareness had positive and 1 per cent level of significant effect on the participation in backward integration. The marginal effect indicates that when a farmer had knowledge about backward integration, the probability of taking part in backward integration was 0.42 per cent greater than others. Farmers who are aware of backward integration technology are actively participating in backward integration as they know the profitability of that technology.

**Table 5.** Probit regression results of factors influencing participation of backward integration

| Variable | Coefficient | Standard Error | Marginal Effect | Standard Error |
|---|---|---|---|---|
| Land tenure | 1.2129*** | 0.3497 | 0.4491*** | 0.1124 |
| Membership of FBO | 0.3350 | 0.4255 | 0.1330 | 0.1676 |
| Awareness | 1.155*** | 0.4041 | 0.4156*** | 0.1198 |
| Distance to market place | 1.8609*** | 0.3973 | 0.6183*** | 0.0912 |
| Farm size | 0.5844*** | 0.1966 | 0.2318*** | 0.0786 |
| Family size | 0.1900 | 0.1386 | 0.0753 | 0.0552 |
| Constant | -5.2258*** | 1.0972 | | |
| Prob > $chi^2$ 0.0000<br>Pseudo $R^2$ 0.5664<br>Log likelihood = -38.4685 | | | | |

Note: ***Significant at 1% level of significance

Distance to market place had a positive significant effect on backward integration at 1 per cent level of significance. The marginal effect indicates that for a farmer having market at a distance less than 100 km have probability of adopting backward integration was 0.62 per cent greater than others. Chilli market for the farmers was nearly 200 km far way but the company market place was very near to farmers, and also companies bearing transportation expenses of the farmer. Farm size had a significant effect on the participation in backward integration. It was positively significant at a level of 1 per cent. The marginal effect indicates that when a farmer had large farm size, the probability of taking part in backward integration was 0.23 per cent greater than others. This confirms the work of Rahman (2017) who argue that land tenure (0.31%), awareness (0.28%) and farm size (0.04%) of the farmers had positive influence to adopt the contract farming technology.

**Poisson Model with Endogenous Treatment**

After looking at factors influencing the adoption of backward integration, the effect of backward integration on the adoption of technologies was analyzed by using poisson model with endogenous treatment. As a result of possible sample selection problem, there was an initial estimation of a selection (backward integration) and substantive equations (adoption of technologies) to correct for such selection problem. The wald test of independent equations shows a chi-square probability of 0.00 indicating that there is no selectivity bias problem in the model. Table 4.4 shows the results from a poisson estimation that indicates the factors influencing the adoption of technologies.

**Table 6.** Maximum likelihood estimation of poisson model with endogenous treatment

| Variable | Coefficient | Standard error | Z-value | P-value |
|---|---|---|---|---|
| Constant | 1.3072*** | 0.2409 | 5.43 | 0.000 |
| Age | -0.0063 | 0.0084 | 0.75 | 0.454 |
| Education | 0.1231 | 0.1050 | 1.17 | 0.241 |
| Credit | -0.0741 | 0.1157 | 0.64 | 0.521 |
| Extension service | 0.1075* | 0.0611 | 1.76 | 0.079 |
| Farming experience | -0.0046 | 0.0100 | 0.46 | 0.645 |
| Backward integration | 0.5322** | 0.2151 | 2.47 | 0.013 |
| Prob > $chi^2$ 0.0000<br>Log likelihood -259.6293 | | | | |

Note: **Significant at 5% level of significance, *Significant at 10% level of significance

The poisson model is estimated using the maximum likelihood method. The goodness of fit parameter of the model indicates that the model adequately predicted the determinants of adoption of technologies. The chi-squared value significant at 1 per cent indicates that all the variables jointly determined the dependent variable. The results indicate that education, extension service and backward integration had a positive effect on adoption of technologies. Extension service was positive and significant at 10 per cent level of significance. The farmers who have access to extension services are more likely to adopt technologies than farmers who have no access to extension service. Reason for the access to extension services are the means through which agricultural technologies are transferred from researchers to farmers by adopting techniques like training and demonstrations. Therefore, access to the extension services facilitates uptake of technology. Farmers who had contact with extension officers have 0.11 per cent greater probability of adoption. Studies by Wanyoike *et al*. (2003) and Sall *et al*. (2000) had shown the access to extension services as very important factor in adoption decisions. Backward integration was positive and had 5 per cent significant level. This indicates that farmers who were participating in backward integration are more likely to adopt technologies than farmers who were not under backward integration. Floyd et al. (2003) observe a positive impact of farmers' on extension service on the adoption of new technologies. Ransom et al. (2003) find irrigated years of fertilizer use, off-farm income and contact with extension as important determinants for adoption of improved maize varieties in Nepal. Rahman (2017) showed that contract farming (0.25%) had a positive influence on adopting improved farm technologies. Farmers who are in backward integration have 0.53 per cent greater probability of adoption. Backward integration affords the farmers the opportunity to use modern inputs, production methods and providing extension services to improve production and quality of output. The use of such improved methods enhances farmer flexibility or resilience to adoption.

## CONCLUSION

- In the total sample of integrated chilli farmers, 46.87 per cent of them are adopting seven technologies and 73.43 per cent of the non-integrated farmers are adopting less than four technologies.
- The land tenure, awareness, distance to market place and farm size of the farmer had positive influence on participation in backward integration. The marginal effect indicates that a farmer with owned land, aware about Backward integration, less market distance and more farm size have a probability of adopting backward integration greater than others.
- Education, extension service and backward integration had a positive effect on adoption of technologies. Extension service and Backward integration were positive and significant at 10 and 5 per cent levels respectively.

**Policy implications**

- Backward integration technology increases output and quality of the produce, so it should be expanded by an assured alternative agency (Government or co-operative) to increase quantity and value of export of chilli.
- Increase in extension service would create knowledge about technologies in chilli farming to farmers because most of the non-integrated farmers are adopting less technologies than integrated farmers.

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